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Trends of major crops productivity to climate variability in Lay Gayint Woreda, Northwest Ethiopia

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Abstract

Climate change is expected to have serious economic, social and environmental impacts in Africa in general and sub-Saharan Africa in particular. Ethiopia is largely an agrarian country with agriculture continuing to be the largest sector in its economy. The country is highly vulnerable to inter-annual climate variation, often cited as one of the important factors in explaining various socio-economic problems such as food insecurity and household vulnerability to poverty. Climate change like higher temperatures and changes in precipitation will directly affect crop yields. It influences crop production and productivity to a greater extent in countries like Ethiopia where agriculture depends largely on natural circumstances. A comparison of yield in a good rainfallyear (1996) with that of a drought year (2001/2002) indicate that the national average yields drop by 40-50% during drought years.. Therefore, The main objectives of this study is to analyze the effect of climate variability on of major crops (Cereals, pulses and oilseeds) productivity trend in Lay Gayint Woreda, Northwest Ethiopia. The study used secondary data on all the variables. The yield data for three major crops: Cereals, pulses and oilseeds wereobtained from South Gondar Agricultural Offices from 1998-2016 whereas climatic data (temperature and rainfall time series) from 1998 –2017 was collected from the Ethiopian Meteorological Services. The Pearson correlation coefficient between the climatic elements and the selected crop yields indicated that the increasing amount of maximum temperature leads to declining the yields of these particular crops and correlation between rainfalls against these particular crops are weak. The multiple linear regression analysis of crops produced in the study area with rainfall and temperature elements of climate explains 14.8 %, 57%, 7.6%, 27.7%, 9.8%, 50.6%, 29% and 53.6 % of the variation of the for teff, wheat, barley, beans, pea, lentils, oilniger and linseed yield respectively can be as a result of the impact of rainfall, minimum and maximum temperature. It is concluded that current climate variability has a significant influence on crop production in the area and any unfavorable change in the local climate in the future will have serious implications for household level food security. This study recommends that efforts to adapt to the ongoing climate change should begin from tackling the current climate variability and take a climate risk management approach for adapting to the ongoing climate change.

Key words: *Climate variability, Crop productivity trend,Correlation and regression analyses*

1.Introduction

Climate variability and change are among the major environmental challenges of the 21st century (Parry et al., 2007). It is an important social and economic issue that threatens the achievement of Millennium Development Goals aimed at poverty and hunger reduction, health improvement and environmental sustainability (UNDP, 2010). Today, there is strong evidence and under-standing that climate change is happening and it is recognized as being one of the greatest challenges of our century. It is anticipated to greatly affect crop production. Worldwide climatic changes have been raising concerns about potential changes to crop yields and crop production system. The increasing atmospheric concentrations of greenhouse gases could lead to regional and global changes in temperature and precipitation. These changes are projected to have impacts on crop production system (IPCC, 2007). There is a growing consensus in the scientific literature that over the coming decades, higher temperatures and changing precipitation levels caused by climate change will depress crop yields in many countries (Yesuf et al., 2008). Crop yield varies from season to season owing to variation in climate during the growing seasons (Ayalew *et al*., 2012). Climate change affect with

increased average annual temperatures, reduced and increased variability in rainfall reduces crop yield and threatens food security in low-income and agriculture-based economies (Meybeck et al., 2012).

Agriculture is highly dependent on climate and a critical part of the economy in most developing countries. Climate change and its variability are emerging as major challenges to agricultural development in the continent with the increasingly irregular and erratic nature of weather conditions placing an additional burden on food security and rural livelihoods (FAO, 2009). According to Hansen (2002), agriculture is the most weather dependent of human activities.

Africa is considered the most vulnerable and disproportionately affected region in the world in terms of climate change as farming is undertaken mainly under rain-fed conditions, increasing land degradation, and low levels of irrigation (FAO, 2011). In the region, climate exerts a significant control on the day to- day economic development, particularly for the agricultural sectors, at regional, local and household scales. Observed global temperature patterns have indicated a greater warming trend since the 1960's (IPCC, 2007). Particularly in Sub-Saharan Africa countries,Climate variability and change is one of the greatest environmental, social and economic challenges facing humanity today and it is a phenomenon that undermines the drive for sustainable development(Tadesse, 2010). Rockström et al., (2004) stated thatAgriculture especially crop production, is heavily dependent on weather events in SSA, where 97% of agricultural land is rain-fed.

Agriculture is the most dominant sector of Ethiopia economy (Gebregziabher et al., 2011). It contributes roughly around 43 percent to overall GDP, 90 percent of export earnings, and supplies 70 percent of the country`s raw materials to the secondary activities (MOFED, 2010). Its dependence on agriculture makes the country particularly vulnerable to the adverse impacts of climate change on crop and livestock productions (Deressa et al., 2008). The sector has experienced steady growth in Ethiopia since 2004, with the overall trend seen as encouraging, both in terms of overall agricultural production and productivity. However, the sector continues to suffer from major structural problems. Despite continued effort to strengthen the sector, agriculture remains low input, low-value and subsistence oriented, and is vulnerable to frequent climatic shocks (GTPII, 2015). Ethiopian agriculture is heavily dependent on rainfall, with irrigated agriculture accounting for less than 1 percent of the country's total cultivated land (MoFED, 2006). In Ethiopia, the distribution of rainfall varies over the diverse agro-ecological zones that exist in the country. In addition to variations across area, the climate is characterized by a history of climate extremes such as drought and flood, and increasing trends in temperature and a decreasing trend in precipitation (MOA, 2000).

In Ethiopia, crop production as a major source of livelihood for most rural communities practicing smallholder farming. It is mainly rain fed and changes in rainfall and temperature patterns are expected to affect its potential (MOFED, 2009). In the region where agriculture is dependent on rainfall, the influence of climate variability on crop production is generally large. Previous studies have shown that variability in Ethiopia's agricultural GDP is clearly correlated with climate variability (World Bank, 2006). In Amhara region, agriculture composed of crop and livestock production is the dominant livelihood source. However, the sector is dependent on traditional modes of production and frequently attacked by erratic rainfall; as a result, the majority of the rural poor are affected by scarcity of food for considerable number of months in a year. The problem is compounded by rampant soil erosion and land degradation and high population pressure. Few studies on impacts of climate variability on crop production have been conducted mostly at national level (Deressa, 2007; Yesuf et al., 2008; Deressa and Hassan, 2009, Weldeamlak, 2009). But not many studies have been done in Ethiopia at local level that gives special emphasis on impact of climate change and variability on crop productivity trend.

Laygayent woreda is chosen as the study area because it is sensitive to climate variability especially erratic rainfall. In the study area, agricultural land is scarce, degraded, overpopulated and

rugged and this is difficult to apply modern inputs to improve the agricultural productivity in which considerable numbers of people are dependent on PSNP for their livelihoods. The woreda is one of the agricultural part of region with a high percentage of subsistent and food crop farmers. There are many manifestations of climatic instability in the last two decades are: floods, several cases of late rains before and persistent droughts during the planting season. Therefore, the aim of this study is to analyze the effects of climate variability on the productivity of selected crops in Lay Gayint Woreda, Northwest Ethiopia

2. Study Area

The study was carried out in Lay Gayint Woreda of South Gondar Zone, Amhara Region, Northwest Ethiopia. Geographically, South Gondar zone is located between 11° 02' -12° 33' N latitude and 37° 25' -38° 43'E longitudes. The zone is bordered in the south by east Gojjam, in the south-west by west Gojjam and Bahir Dar, in the west by Lake Tana, in the north by north Gondar, in the north-east by Wag Hemra, in the east by north Wollo, and in the south-east by South Wollo; the Abbay River separates South Gondar from East and West Gojjam Zones (Bureau of Agriculture/BOA, 2012).

Lay gayent woreda covers a total area of 1,320.31 km2 composed of 29 rural and two urban kebeles (the lowest administrative unit of Ethiopia) with a total population of 242,306, the population density is about 184 persons per square kilometer. The population density of the study area is higher than in the Amhara region (112 persons per square kilometer) (CSA, 2006) and the nation's average (67 persons per square kilometer) (EDHS, 2012). About 10% live in urban and the remaining in rural areas. Given the fragile ecosystem and the rugged terrain, the population density in the woreda is well above its carrying capacity. Aklilu et al. (2000) indicated that in Lay Gaint woreda total area cropped had increased but land owned per household had dramatically decreased due to high population pressure and there is uneven population distribution exists in the woreda.

Lay Gaint is the fifth largest woreda and accounts for 11% of the total area in South Gondar Administrative zone. The woreda town, Nefas Mewcha is located 741 km a road distance away from Addis Ababa and 175 km a road distance far from Bahir Dar.The woreda is bordered by Mekiet woreda in the East, Ebinat and Bugina in the North, Estie and Farta in the West and Simada and Tach Gayint in the South. It is one of the 10 Woredas under South Gondar zone. The wereda lies within the geographical grid coordinates of $11^{o}32'$-$12^{0}16'$ N latitude and $38^{0}12'$-$38^{0}19'$ E longitude (Lay Gayint Woreda Agriculture Development Office/LGWADO, 2011).

Agro-ecologically, the southwestern part of the woreda is dominated by Dega agro-ecology with gentler slope but the central and the northern parts of the woreda are characterized by Woina-Dega and Kolla agro-ecological zones, respectively have steeper slopes. About 75% of the total area in the Dega zone is gentler slope with better soil fertility, while 90% of the Kolla zone is steeper slope exposed for severe soil erosion and covered with infertile soils (Aklilu et al., 2000). In general, the relief of the woreda is composed of mountainous (15%), flatland (10%), rugged topography (70%) and dissected valleys (5%) (Woreda Agricultural Office /LGWAO, 2011). Based on the information obtained from South Gondar Zone Information and Communication Office (2010), Most of the rural population settled in the highlands and plateau areas. The main soil types in the woreda are brown (55 %), red (15 %), black (15 %), grey (10 %) and other soil type (5 %) (LWADO, 2011).

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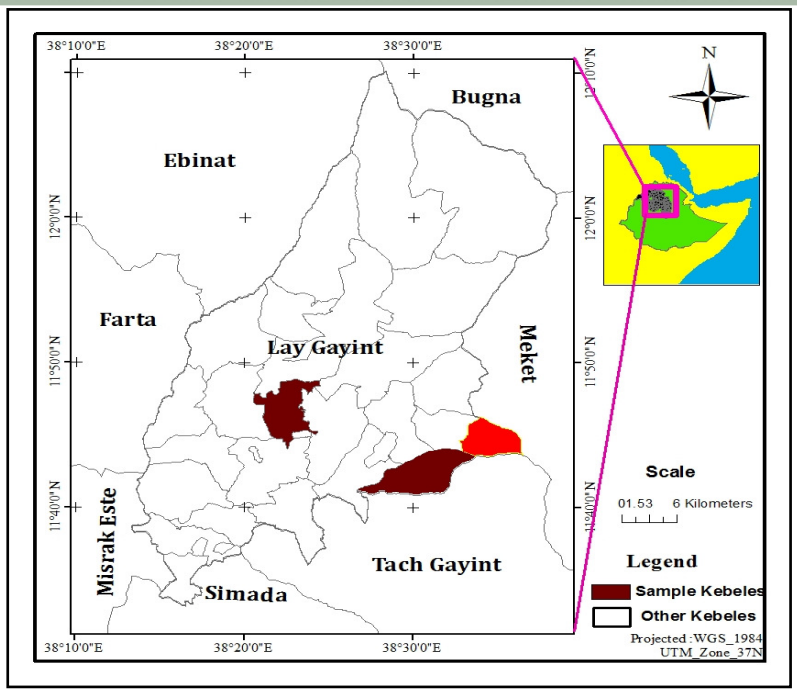

Figure 1: Location map of the study area [Source: Computed based on Ethio- GIS database]

According to Lay Gaint Woreda Agriculture Office (2011), the mean minimum and mean maximum temperature for the study woreda ranges between 50C and 24^{0}C respectively. Specifically, mean annual maximum temperature is the highest from March to May and mean annual minimum temperature is the lowest from December to January. The rainy seasons in the study area include Belg (little rain) and heavy Kirmet (heavy rains) with erratic distribution varying from 600 mm to about 1200 mm.

Agriculture is the main economic activities and is dominated by small-scale and mixed crop and livestock farmers. Crop production is mainly rain-fed, except in very specific and small areas where vegetables are cultivated using traditional and small scale irrigation. However, the sector is dependent on traditional modes of production and frequently attacked by erratic rainfall; as a result, the majority of the rural poor are affected by scarcity of food for considerable number of months in a year There are two rainy seasons; 'keremt' and 'Belg' which are used for the cultivation of both long and short cycle crops. Wheat, teff, maize, sorghum, barely, cheek pea, beans and oil crops) are the major crops grown in the area (LWAO, 2013). Crop production failed because of the late onset and early terminated rains. The problem was compounded by high intensity of rainfall associated with hailstorms, landslides and severe soil erosion in the two wet months (July and August) (LWAO, 2013). Livestock are kept for complementary purpose thereby livestock and livestock products sales have considerable contribution to household's income and food security.

Table 1: Lay Gayent Woreda land use classification

Land use type	Hectare	%
Cultivated land (annual crops)	68649	44.32
Communal Grazing land	22160	14.31
Shrubs land	8150	5.26
Water body	3665	1.69
Bar land	52,540	33.93
Infrastructure, Settlement & others	2344	1.51
Total	154,866	100.0

Source: Lay Gayent woreda agricultural office, 2012

3. Data And Methods

3.1. Data collection

The study used secondary data on all the variables. The data used for this study are historical rainfall and temperature records and time series data from 1998 to 2016 collected from Nefas Mewcha Station and Global Weather Data for Soil and Water Assessment Tool (http://globalweather.tamu.edu), and productivity of major crops: Cereals: barley, teff, wheat pulses: beans, pea and oilseeds: lentil, oilniger and linseed grown in the area for the main cropping season, locally known as Meher that contribute more than 80% of the total grain production in the woreda.Crop production data was obtained from the south Gondar agricultural office from 1998-2017. In addition, other published and unpublished literatures were consulted in the whole process of the research.

3.2. Data analysis

To determine productivity variation, relationship and effect of climatic variables, namely rainfall (annual rainfall) and temperature (maximum and minimum) on crop production in the study area, correlation and regression analyses were used.

4. RESULTS

4.1. Major crop's productivity trend in the study area

1. Trends of Cereal Crops

Ethiopia's crop agriculture is complex, involving substantial variation in crops grown acrossthe country's different regions and ecologies. Cereals dominate Ethiopian crop production: five major cereals (teff, wheat, maize, sorghumand barley) are the core of Ethiopia's agriculture and food economy, accounting for aboutthree-quarters of total area cultivated, 29 percent of agricultural GDP in 2005/06 (14 percentof total GDP) and 64 percent of calories consumed (http://faostat.fao.org/). There has been substantial growth in cereals, in terms of area cultivated, yields and production since 2000, but yields are low byinternational standards and overall production is highly susceptible to weather shocks,particularly droughts.

Cereal production has increased annually by 3% between 1960 and2000(CSA, 2000). Cereals were grown on 73.4 percent of the totalarea cultivated, by a total of 11.2 million farmers. Together, these holders produce a yearlyaverage of 12 million ton of cereals, which is 68 percent of total agricultural production. Teff accounts for 28 percent oftotal cereal area, while maize stands for 27 percent of total annual cereal production. Thus, both raising production levels and reducing its variability areessential aspects of improving food security in Ethiopia, both to help ensure adequate foodavailability, as well as to increase household incomes.

Ethiopia is the center of origin and diversity for teff**.** The crop is highly adapted to diverse agro ecological zones including conditions marginal to the production of most other crops. It is cultivated in high rainfall areas with long growing periods. It can also grow in low rainfall and drought prone areas characterized by protracted growing seasons and frequent terminal moisture stress. It tolerates reasonable levels of both drought and water logging better than most other cereals. The cultivation of teff in Ethiopia has partly been motivated by its relative merits over other cereals in the use of both the grain and straw (MOFED, 2005)

The trends of teff productivity for the 19 years period from 1998/99-2016/17 in the study area are presented in figure 2. The figure shows that there were wide fluctuations in teff productivity. There was remarkable increase in yield productivity in the year 2003/04, 2010/11, 2012/13, 2013/14 and 2016/17. However, the productivity of teff decreased in the year 2001/02 and 2005/06 and the remaining years were average productivity of the crop. Over 19 years (1998/99- 2016/17), average yield productivity of teff was estimated to be 6.09 q/ha.

Wheat is the fifth most important cereal crop in Ethiopia. In area of production, it ranks 5th after teff, maize, barley and sorghum and in total grain production. It is an important crop commodity, which could contribute a major part in achieving the country's agricultural policy objective of food grain self-sufficiency (EARO, 2000). According to the report of Agricultural office in the study area, the wheat productivity data show that from the year 2007/8- 2016/17, there was considerable increase in wheat production from 9.27 q/ha and 19.25q/ha respectively. During the period of 2006/07, there was a distinct decrease within the productivity of 1.47q/ha. The overall productivity of the crop has an increasing trend with 11.28q/ha.

Barley is the fourth most important cereal crop in the world after wheat, maize, and rice, and is among the top ten crop plants in the world (Akar et al., 2004). According to the 2014/2015 forecasts from Ethiopia's Central Statistics Authority, of the 12.6 million hectares under cultivation of the grain crops, 80.78% was under cereals which contributed 87.36% of the grain production and Barley took up about 8 and 7 percent of the grain crop area, and production respectively (CSA,2014). According to the report, barley production and the respective productivity of the year become an increasing order generally from year to year, even though there was some fluctuation in area harvested which is measured in hectare. The maximum productivity of barley in the study area were occurred 2003/04, 2008/09, 2015/16 and 2016/17&2002 years of production. While the least or minimum productivity were recorded in the year 2011/12 (Figure 2).

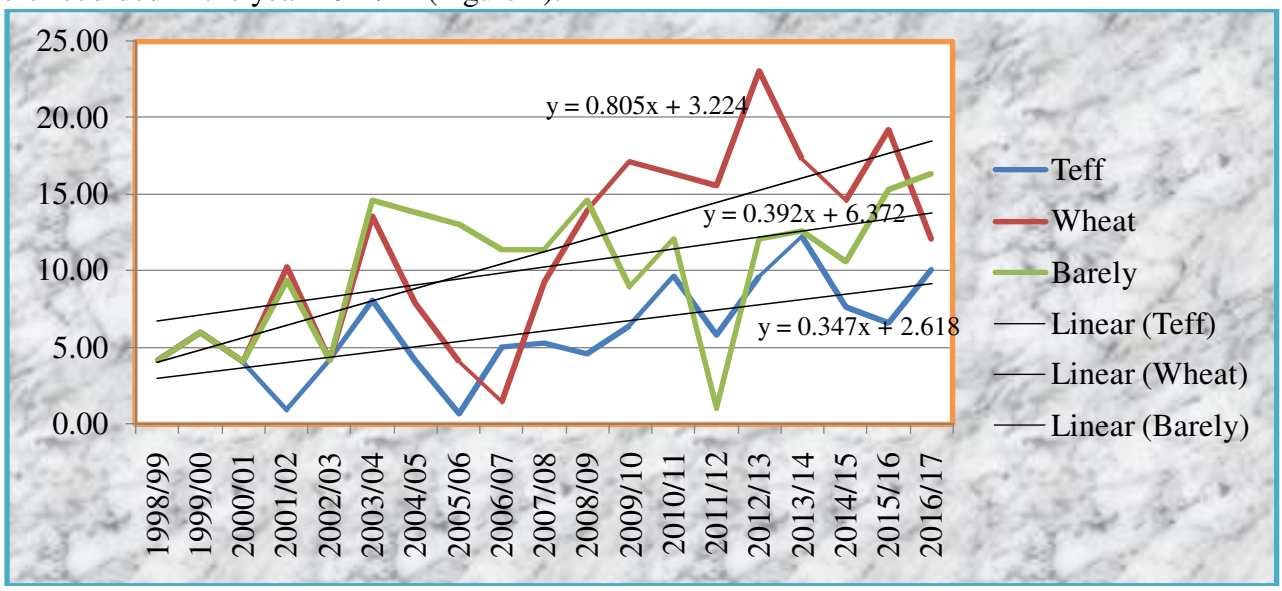

Figure 2: Cereal crops productivity in Lay Gayent wored (1998/99-2016/17)

2. Trends of pulses

After cereals, the second most important crop group (in terms of acreage) in Ethiopia is pulses.

The pulse industry has developed significantly with little intervention, and great potential exists toincrease the production and impact of pulses through proactive and targeted support. Ethiopia's pulses sector has experienced tremendous growth in the last five years and is now the second-largest component of Ethiopia's agricultural sector and an important part of Ethiopia's gross domestic product (EATA,2015).Rough calculations suggest that Ethiopia could expand its foreign market presence by at least doubling its current exports through increased production levels (CSA, 2008). In 2004/05-2007/08 6.4 million holders grew pulses on 12.4 percent of total area cultivated. Total pulse production averaged 1.5 million tons per year, which is 8.5 percent of total crop production. The country is now one of the top ten producers of total pulses in the world, the second-largest producerof faba beans after China, and the fifth or sixth largest producer of chickpeas. Within Ethiopia, pulses are the third-largest crop export behind coffee and oil seed, and represent a USD 90 million export industry (FAO, 2008).

Different pulse species are grown in the country. While pulses are grown throughout the country, and account for 13 percent of cropped land area, production is concentrated in the Amhara and Oromiya regions, which together account for 92 percent of chickpea production, 85 percent of faba bean production, 79 percent of haricot bean production, and 79 percent of field pea production. Amhara region also brings forward the largest producer of three out of the four major pulses varieties in the country (faba beans, chickpeas, and haricot beans). The primary producers of pulses are smallholders with small and dispersed plots under rain fed conditions, while
Oromiya leads production in the other major variety - field peas (ECSA, 2015).

In Ethiopia, bean is one of the most important cash crops and source of protein for farmers in many lowlands and mid-altitude zones. The country's export earnings is estimated to be over 85 % of export earnings from pulses, exceeding that of other pulses such as lentils and chickpea (Negash, 2007). Overall, bean ranks third as an export commodity in Ethiopia, contributing about 9.5 % of total export value from agriculture (FAO, 2010).

The trends of bean productivity for the 19 years period from 1998/99-2016/17 in the study area are presented in figure 3. The figure shows that there were wide fluctuations in beans productivity. There was remarkable increase in yield productivity in the year 2001/02, 2004/05, 2005/06 and 2009/10. However, the productivity of bean declining in the year 2000/01 and 2002/03 and the remaining years were average productivity of the crop. Over 19 years (1998/99- 2016/17), average yield productivity of bean was estimated to be 7.78 q/ha.

Ethiopia has the highest yield gain of pea among the top 10 producing countries in the world (FAO, 2016). Its share in the global pea export market is very limited: average about 4% by value and volume. However, it accounts for 63.5% of the total pea export from Africa (ranks first in Africa). Currently, Ethiopia's chickpea export earnings also grew substantially (FAO, 2016)

Nineteen years pea productivity is presented in figure 3.The results show increasing trend of pea during the 19 year period (1998/99-2016/17) under study. The productivity of pea was declining continuously from the year 2002/03-2003/04. The highest productivity were recorded in the year 2004/05, 2009/10 and 2016/17 that accounts 10.87q/ha in average production.

Lentil is one of the less selective legumes in terms of climate and soil features (Ozdemir, 2002). It is the most important crop because of its high protein content and fast cooking characteristic. Productivity of lentil in Ethiopia varies from region to region due to variation in environment and biotic factors. Currently, lentil is considered as a cash crop that fetches higher price compared to most of the cereals and pulses grown in Ethiopia. It has huge potential of reducing poverty and contributes to sustainable economic development in Ethiopia. Despite the country's potential and sustained development efforts to get the pulse sub-sector moving, the competitiveness of lentil and hence its contribution to economic development is threatened by low productivity and inconsistent supply of products that does not met both export quality and quantity. On the other hand, the ever increasing population and ever changing client demand of lentil is the good opportunity for boosting production at farm level (Abraham, 2015). The productivity trend declined from 2004/05-2007/08. The decline was as a result of the adverse weather conditions in the form of drought. Since 2009/10, lentil productivity improved marginally until 2011/12.

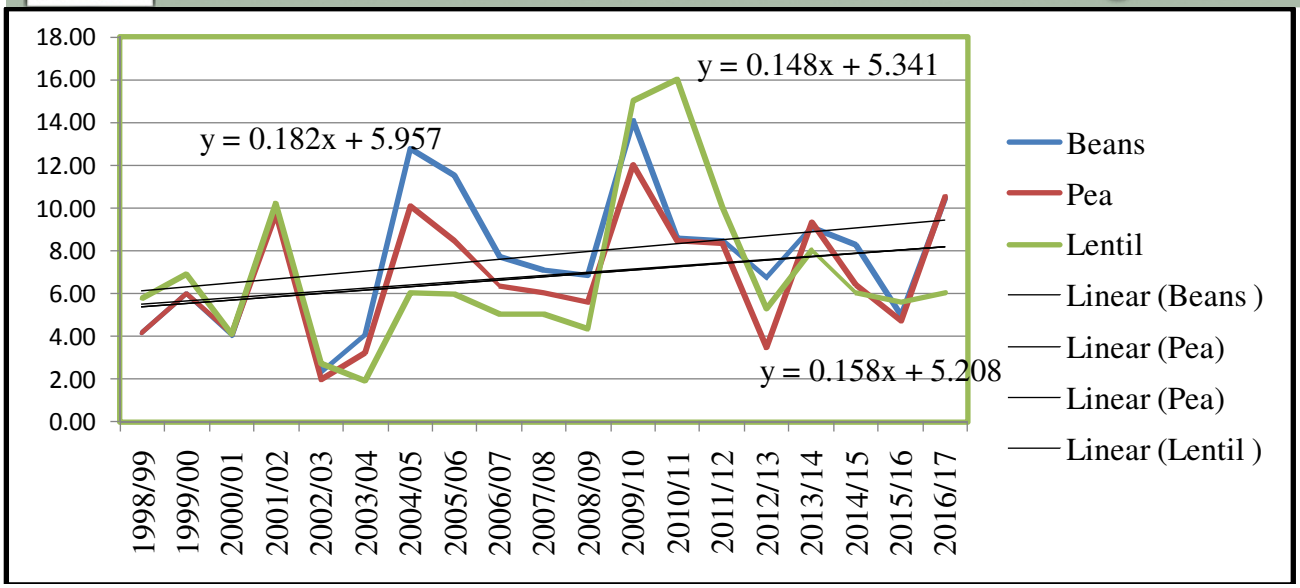

Figure 3: Trend in productivity of pulses in Lay Gayent woreda, 1998/99-2016/17

3. Trends of oilseeds

In Ethiopia, Oilseeds form the third most important crop group. It is cultivated on 6.9 percent of total area cultivated, by 3.1 million holders. They produce an average of 0.5 million ton of oilseeds yearly, i.e. 3 percent of total annual production (CSA, 2008). A variety of oil seeds are grown in Ethiopia, of which sesame is by far the most important both in terms of volume (see Figure 2), value and export earnings. The oilseeds produced are supplied both for the local and international market, in which especially sesame has become a major foreign currency earner for Ethiopia with exports all over the world, especially to China, India and the European Union. Sesame accounts for over 90% of the values of oilseeds exports from Ethiopia to the world. The country is the second largest sesame exporter in the world after India and sesame is second only to coffee in foreign exchange earnings (Boere, A. et al., 2015)

The productivity trend of yields for oilniger shows very different patterns. Thus, yield of oilniger has increased from 0.84q/ha in 2010/11 to 7.95q/ha in 2016/17. Except for the year 2001/02, during which the yield of oilniger increasing sharply, it has stagnant productivity trend in the study area from the year 1998/99-2008/09. Linseed is mainly used for domestic consumption in Ethiopia. As can be seen figure below, there is relatively stagnant productivity trend in the study area up to the year 2009/10 except in the 2001/02 which recorded the highest productivity.

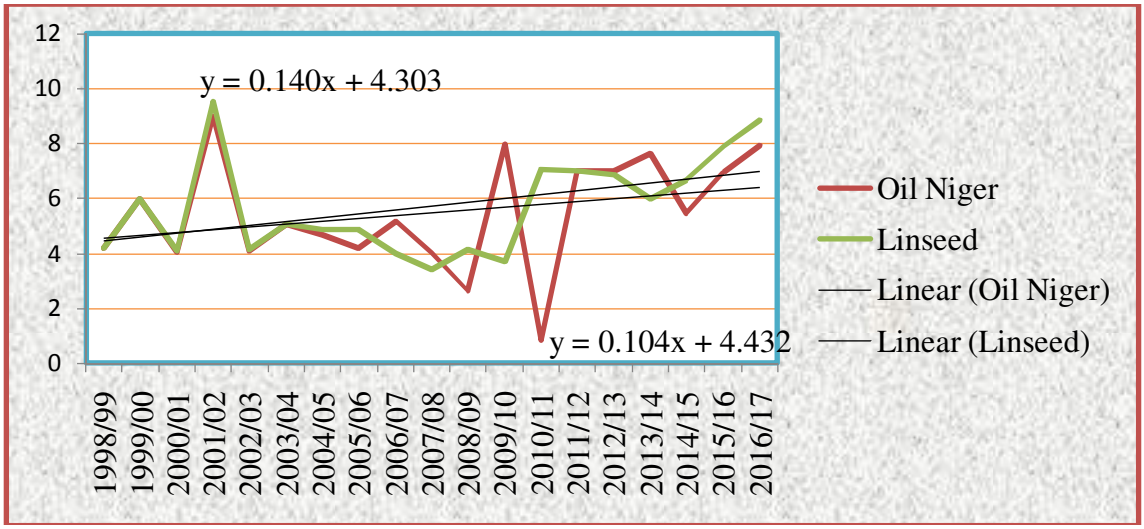

Figure 4: Productivity trends of oilseeds in Lay Gayent woreda (1998/99-2016/17)

4.2. Climate variability and crop productivity

Wheat, barley, lentils and linseed yield shown an increasing trend with a trend coefficient of 13.59, 5.43, 0.001 and 0.003 quintals per year respectively for the study area while teff, bean, pea and oilniger yield shown a decreasing trend with a trend coefficient of 10.87, 0.0002, 0.0002 and 0.0023 quintals per year. Trend of wheat, barley, pea, lentils and oilniger yield are statistically significant at 1% and 5% while trend of teff, bean and linseed are not statistically significant.

Out of the total selected crops, linseed has the lowest mean yield value 10973.94 quintals per year while wheat has the highest mean yield value 118170.42 quintals for the study area (see table 1). The maximum value for teff, wheat, barley, beans, pea, lentils, oilniger and linseed were 94971.00, 270978.00, 115778.00, 54983.00, 64980.00, 15264.00, 5305.00, 22273.00 quintals per year respectively whereas the minimum values for teff, wheat, barley, beans, pea, lentils, oilniger and linseed were 2759.00, 14776.00, 37864.00, 2214.00, 1138.00, 19.00, 46.00, 152.00 quintals per year respectively.

Table 2: Descriptive and Trend Analysis of Crop Yield Data from 1998-2016/17

Descriptive Statistics							
Major crops	**N**	**Minimum temperature**	**Maximum temperature**	**Mean**	**Std. Deviation**	**Correlation Coefficient**	**Trend Coefficient**
Teff	19	2759.00	94971.00	47066.3684	23998.48980	-.019	-10.87
Wheat	19	14776.00	270978.00	118170.4211	75481.47894	.688**	13.59
Barley	19	37864.00	115778.00	67068.2632	21744.08181	.091**	5.43
Beans	19	2214.00	54983.00	22888.4211	17465.81474	-.575	-.0.0002
Pea	19	1138.00	64980.00	23614.4211	17947.54336	-.507*	-.0.0002
Lentils	19	19.00	15264.00	5350.4211	4344.82296	.739**	0.001
Oilniger	19	46.00	5305.00	1877.4211	1797.33365	-.746**	-0.0023
Linseed	19	152.00	22273.00	10973.9474	7786.84661	.377	0.0003

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Correlation Analysis

The Pearson correlation coefficient between the climatic elements and the selected crop yields were computed and the result is presented in table 2. This analysis indicated that the correlation value of maximum temperature against bean and oilniger is greater than 0.5 and statistically significant at 0.05 significance level and shows positive correlation between beans and oilniger with maximum temperature. On the other hand, the correlation value of maximum temperature against wheat, lentils and linseed is greater than 0.5 and statistically significant at 0.001 significance level .Hence, the increasing amount of maximum temperature leads to declining the yields of these particular crops.

The correlation value of minimum temperature against bean and oilniger is greater than 0.5 and statistically significant at 0.05 significance level and shown positive correlation exists between beans and oilniger with minimum temperature. On the other hand, the correlation value of minimum temperature against wheat, lentils and linseed is greater than 0.5 and statistically significant at 0.001 significance level.Hence, the increasing amount of maximum temperature leads to declining the yields of these particular crops (See Table 2).

The correlation value of rainfall against beans and pea are negative and are not statistically significant. On the other hand, the correlation between rainfalls against teff, wheat, barley, lentils, oilniger and linseed for this study has shown positive correlation exists between them but less than 0.5. This indicates that the correlations between rainfalls against these particular crops are weak

* Correlation is significant at the 0.05 level (2-tailed)

Woreda	Crop type	Maximum temperature	Minimum temperature	Rainfall
Lay Gayent	Teff	-0.332	-0.318	0.091
	Wheat	-0.728**	-0.707**	0.05
	barley	-0.125	0.026	0.186
	Beans	0.523*	0.463*	-0.086
	Pea	0.285	0.238	-0.013
	lentils	-0.706**	-0.607**	0.172
	oilniger	0.503*	0.483*	0.038
	linseed	-0.72**	-0.584**	0.255

**Correlation is significant at the 0.01 level (2-tailed)

Regression Analysis

The multiple linear regression analysis of crops produced in the study area with rainfall and temperature elements of climate is presented in table 2. The results shows that the adjusted R of this model -.023, 0.484, -0.109, 0.133, -0.082, 0.407, 0.148 and 0.444 with the R^2=.148 , 0.57, 0.076, 0.277, 0.098, 0.506, 0.29 and 0.536shown that the multiple linear regression explains 14.8 %, 57%, 7.6%, 27.7%, 9.8%, 50.6%, 29% and 53.6 % of the variation of the for teff, wheat, barley, beans, pea, lentils, oilniger and linseed yield respectively can be as a result of the impact of rainfall, minimum and maximum temperature. The F-ratio which determines the overall significance of regression is statistically significant at 10% level of probability as F-calculated value (6.639, 5.121 and 5.785) for wheat, lentils and linseed respectively is greater than F-tabulated value. Therefore, it can be concluded that climate change significantly affect teff yield. On the other hand, the F-ratio which determines the overall significance of the regression is not statistically significant even at 10% level as F-calculated value (.865, .409, 1.919, .545, and 2.045) is less than F- tabulated value. To this effect, it will be concluded that there is no significant relationship between climate change and Teff, barley, Beans, Pea and oilniger yield.

Table 3: Regression Analysis

Woreda	Crop	R	R^2	Adjusted R	F	Significance
Lay Gayent	Teff	.384	.148	-.023	.865	.481
	Wheat	0.755	0.57	0.484	6.639	0.005**
	barley	0.275	0.076	-0.109	.409	.749
	Beans	0.527	0.277	0.133	1.919	0.17
	Pea	0.314	0.098	-0.082	.545	.659
	lentils	0.711	0.506	0.407	5.121	.012**
	oilniger	0.539	0.29	0.148	2.045	.151
	linseed	0.732	0.536	0.444	5.785	.008**

** Correlation is significant at the 0.01 level (2-tailed)

Prediction Model

The model of multiple regression analysis predicts that an increase in maximum temperature will cause an increase in yield of teff, wheat, pea, lentils, oilniger and linseed and pea yield and whereas an increase maximum temperature will cause a decrease in yield of barley and beans(table

4).On the other hand, an increase in minimum temperature will cause an increase in yield of barley and beans whereas an increase in minimum temperature will cause a decrease in yield of teff, wheat, pea, lentils, oilniger and linseed.

An increase in rainfall will cause an increase in yield of teff, beans, pea and oilniger yields whereas an increase in rainfall will cause a decrease in yield of wheat, barley, lentils and linseed production (table 4).

Table 4: Prediction Model

Woreda	Parameter	Teff	wheat	Barley	beans	Pea	lentils	oilniger	linseed
		B	B	B	B	B	B	B	B
Lay Gayent	Constant	79350.3	480090.6	87306.21	-38947.4	-23263.1	24080.79	-5974.31	41614.11
	Rainfall	2507.296	-4455.37	-4424.66	1955.3	3375.92	-415.345	392.446	-508.477
	Minimum T0c	-12978.5	-29611.9	11345.76	1274.388	-5685.9	-1066.29	-398.736	-2539.16
	Maximum T0c	42.824	47.894	-21.597	-0.12	23.586	3.234	2.694	10.684

Discussion

The agriculture sector has experienced steady growth in Ethiopia since 2004, with the overall trend seen as encouraging, both in terms of overall agricultural production and productivity. However, the sector continues to suffer from major structural problems. Despite continued effort to strengthen the sector, agriculture remains low input, low-value and subsistence oriented, and is vulnerable to frequent climatic shocks (GTPII, 2015).

Smallholder farmers, whose output is predominantly cereal crops, account for 95% of agricultural production in Ethiopia (MOA, 2016). Maize, wheat, and teff are the most important cereals in terms of volume, accounting for a combined total of 77% of all cereal production, but barley, sorghum and millet are also widely grown. Pulses and oilseeds constitute other major crop types grown for domestic consumption and export, including chickpea, sesame, sunflower, groundnut, and various beans (CSA, 2014).

Increased productivity in the agriculture sector has contributed significantly to Ethiopia's outstanding economic growth over the past decade. In Lay Gayint Woreda, crop production is characterized by rain-fed, traditional, small scale, subsistence orientated and labour intensive based on family labor. Due to the diversity of climatic and soil condition, different types of crops grow like cereals, pulses, oilseed and root crops such as potatoes which are the major ones.

According to the report of Agricultural office in the study area, the overall productivity of cereal crops are increasing trend. This result is coincide with the report of CSA(2015) which states that overall cereal production (tef, wheat, maize, sorghum and barley) showed remarkable increases over the last six years, for example, with growth rates of 63% in production and 41% in productivity. Nevertheless, because of its subsistence-based orientation, many of the gains in the agriculture sector are not yet translating into market development and overall transformation.

In addition Zerihun (2012) in his study stated that while there are regional variations in yields for the three major cereal crops, regional and zonal changes in crop yields over the 28 years period largely followed the national trends and he observed that maize yield has increased over 50 percent over 28 years while teff and wheat have shown an annual increase of 1 percent.

This finding is supported by FAO(2013) statistics; the cereal yield per hectare has increased since 1989. During the time period 1991 to 2004 the harvest are averaging around 800 Kg/ha. Between 2008 and 2011 the average yield had increased to more than 1200 Kg/ ha. The area used for cereal production has also increased between 1993 and 2012. Comparing the area harvested in 1993 with the area harvested in 2012 the area has more or less doubled in size. The total production of cereals is two and a half times greater in year 2012 compared to 1993. In terms of total cereal production there has been a big increase. In Amhara region the teff production has almost doubled between 2004 and

2011.This result is consistence with the findings of Arega (2013) that the general tendency of crop production in the lay gayent woreda exhibited a declining trend with high inter-annual variations. In some years, production was higher, and lower in others. For example, between 2009 and 2011 production was higher but abruptly decreased in 2013. Hence, the variations of crop production, which are the main cause of food insecurity, are the direct reflection of rainfall variability. If agricultural production in the low-income developing countries is adversely affected by rainfall variability, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased (FAO, 2008). For example, in the years, 2001 and 2002, the amount of rainfall was low in the study area, and it significantly decreased the amount of crop production. In general, in drought-prone areas, such as Lay Gaint, the most important determinant factor for crop production is the availability and distribution of rainfall. In the recent history of Lay Gaint district, the year 2012/2013 can be taken as the most disastrous year. As the district agricultural expert indicated, crop production failed because of the late onset and early terminated rains. The problem was compounded by high intensity of rainfall associated with hailstorms, landslides and severe soil erosion in the two wet months (July and August). Woldeamlak (2009) also noted that besides the very low levels of productivity, Ethiopian agriculture is also characterized by wide fluctuations in total output from year to year. The year-to-year fluctuations are caused mainly by the inter-annual rainfall variability.

The maximum productivity of barleyin the study area were occurred 2003/04, 2008/09, 2015/16 and 2016/17&2002 years of production. This result is in line with the CSA (2014) report that Between 2003/04 and 2013/14, the number of smallholders growing barley increased from 3.5million to 4.5 million; yields increased from 1.17metric tons per hectare to 1.87 metric tons per hectare; and total production grew from 1.0million tons in 2005 to about 1.9 million tons in 2014 (CSA, 2014). According to CSA of Ethiopia, the output from area harvested of barley is increasing from 2010/2011 to 2014/2015 due to efficient utilization of the inputs like fertilizers and applying appropriate agronomic practice and modern technology to the crop

In the study area, there were wide fluctuations in beans productivity. There was remarkable increase in yield productivity in the year 2001/02, 2004/05, 2005/06 and 2009/10. Legesse et al., (2006) in his study pointed out that in the major beans producing areas of Ethiopia, production is generally trending upwards. Both area and yield have been growing at a positive average rate since 2002 in response to economic reforms of 1990s. The results also show increasing trend of

pea during the 19 year period (1998/99-2016/17) under study. This was also recognized by FAO (2016) that states currently Ethiopia's chickpea export earnings also grew substantially. This result is inconsistence with the findings of Aklilu et al., (2000) as cited in Arega (2013) in Lay Gaint woreda indicated that total production of the major pulses such as beans and peas showed a declining trend because of drought, hail damage, soil degradation and diseases.

Regarding tooilseeds,many smallholders and a limited number of large farms grow oilseeds. Oilseeds are cash crops on subsistence farms. Its production is characterized as labour intensive, low-input and rain-fed. The potentials to increase the production are huge. Productivity per ha for most oilseeds can be doubled with higher input levels and improved technologies (CSA, 2014). Ethiopia ranks among the top 5 world producers of sesame seed and linseed. It is also an important producer of Niger seed. The growing demand in the world market for these specialty products and the available capacity to expand production could make oilseeds turn into one of the engines of economic growth of Ethiopia. Oilseeds are produced on a limited scale. Amhara region is one of the main production areas of sesame seed in Ethiopia (Bennet, 2004).

In the study area, lentil productivity declined from 2004/05-2007/08. The decline was as a result of the adverse weather conditions in the form of drought. Since 2009/10, lentil productivity improved marginally until 2011/12. The productivity trend of yields for oilniger shows very different patterns. Thus, yield of oilniger has increased from 0.84q/ha in 2010/11 to 7.95q/ha in 2016/17. Except for the year 2001/02, during which the yield of oilniger increasing sharply, it has stagnant productivity trend in the study area from the year 1998/99-2008/09. Linseed is mainly used for domestic consumption in Ethiopia. There is relatively stagnant productivity trend in the study area up to the year 2009/10 except in the 2001/02 which recorded the highest productivity.

CONCLUSION

Lay Gayint Woreda is one of the agricultural parts of region with a high percentage of subsistent and food crop farmers.Crop production is the major livelihood strategy for the majority of the households and it characterized by rain-fed, traditional, small scale, subsistence orientated and labour intensive based on family labor. Due to the diversity of climatic and soil condition, different types of crops like Cereals, pulses and oil seeds are the major crops grown in the woreda. According to the report of South Gondar zone Agricultural office agricultural office data the overall Crop productivity shows an increasing trend for the last nineteen years from 1998-2017.

There were wide fluctuations in teff productivity. There was remarkable increase in yield productivity in the year 2003/04, 2010/11, 2012/13, 2013/14 and 2016/17. The wheat productivity data show that from the year 2007/8- 2016/17, there was considerable increase in wheat production from 9.27 q/ha and 19.25q/ha respectively. The maximum productivity of barleyin the study area were occurred 2003/04, 2008/09, 2015/16 and 2016/17&2002 years of production. The study also found out that, there were wide fluctuations in beans productivity. There was remarkable increase in yield productivity in the year 2001/02, 2004/05, 2005/06 and 2009/10. The results also show increasing trend of pea during the 19 year period (1998/99-2016/17) under study. Regarding tooilseeds**,** many smallholders and a limited number of large farms grow oilseeds. Oilseeds are cash crops on subsistence farms. Its production is characterized as labour intensive, low-input and rain-fed. The study reveals, lentil productivity declined from 2004/05-2007/08. The decline was as a result of the adverse weather conditions in the form of drought. Since 2009/10, lentil productivity improved marginally until 2011/12. The productivity trend of yields for oilniger shows very different patterns. Thus, yield of oilniger has increased from 0.84q/ha in 2010/11 to 7.95q/ha in 2016/17. Except for the year 2001/02, during which the yield of oilniger increasing sharply, it has stagnant productivity trend in the study area from the year 1998/99-2008/09. Linseed is mainly used for domestic consumption in Ethiopia. There is relatively stagnant productivity trend up to the year 2009/10 except in the 2001/02 which recorded the highest productivity.

Based on the Trend Analysis of Crop Yield Data from 1998-2017, wheat, barley, lentils and linseed yield shown an increasing trend with a trend coefficient of 13.59, 5.43, 0.001 and 0.003 quintals per year respectively for the study area while teff, bean, pea and oilniger yield shown a decreasing trend with a trend coefficient of 10.87, 0.0002, 0.0002 and 0.0023 quintals per year. Trend of wheat, barley, pea, lentils and oilniger yield are statistically significant at 1% and 5% while trend of teff, bean and linseed are not statistically significant.

The Pearson correlation coefficient between the climatic elements and the selected crop yields indicated that the correlation value of maximum temperature against bean and oilniger is greater than 0.5 and statistically significant at 0.05 significance level and shows positive correlation between beans and oilniger with maximum temperature. On the other hand, the correlation value of maximum temperature against wheat, lentils and linseed is greater than 0.5 and statistically significant at 0.001 significance level .Hence, the increasing amount of maximum temperature leads to declining the yields of these particular crops. The model of multiple regression analysis predicts that an increase in maximum temperature will cause an increase in yield of teff, wheat, pea, lentils, oilniger and linseed and pea yield and whereas an increase maximum temperature will cause a decrease in yield of barley and beans.

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